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Art. IV.—*Cherty Limestone with* Planorbis, *from the Mount Elder Range, Western Australia.*

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Contents.

1.—Locality and Occurrence.

The samples examined were collected by Dr. Arthur Wade, F.G.S., in May, 1924, during his explorations in the Kimberley District and in the Northern Territory. Dr. Wade's own reference to the occurrence is as follows (Wade, 1924, p. 29):—

> "On the crests of the Mount Elder Range grey, green, and white cherts rest on the chocolate coloured sandstones. Along the junction the sandstones have a peculiar mammillated struture, due, apparently, to partial solution by meteoric waters. The cherts show evidence of being siliceous replaeements of limestone beds. Near Trig. J. 40 the cherts are crowded with *Planorbis hardmani* (Foord) [evidently a *lapsus calami* for "McCoy"], which has been determined as a Tertiary freshwater form. This cairn at the Trig. Station is formed of blocks of this fossiliferous chert. It would appear that these cherts are the residual remains of deposits laid down in an inland lake in Tertiary times. At present they are perched on the crests of hills nearly 1,000 feet above sea level, and over 600 feet above the level of the Ord River. This is an indication and rough measure of the amount of denudation that has taken place in this region since the Tertiary period, which one cannot help regarding as remarkable."

In Hardman's admirable report on the Geology of the Kimberley District (Hardman, 1885, p. 7), we read:—

> "On the other side of the Ord, and about 25 miles to the N.E. is a low range of hills trending N.W. and S.E. for 12

or 15 miles. The northern extremity of this has been named Mount Elder by Mr. A. Forrest, but the highest point lies near the S.E. extremity; it is marked on the map as J.40, and is 987 feet above sea-level. The main portion of this range is composed of Carboniferous rocks, chiefly sandstones and grits, with ironstones, capping the limestones of the flat country beneath; but at the summit of J.40 there is a small patch of white limestones, soft sandstones and chert, the last containing quantities of a gasteropod shell, which Prof. McCoy, of Melbourne University, has determined to be a new species of *Planorbis*, and which he has named *Planorbis hardmani*. This small outlier, which rests unconformably on the Carboniferous rocks, must therefore be of Upper Tertiary age, and is the only remnant of a formation, which probably, formerly widely overspread this district, but has been long since removed by the forces of atmospheric denudation—in this country of tropical rains and intense heat, exceedingly powerful."

No actual measurements of thickness have been given for this *Planorbis* limestone. Dr. Wade, however, in his Table of General Geological Sequence in the Kimberley Report (1924, p. 9), gives the approximate thickness of the Tertiary formation of that area—including clays with crustacea of Anson Bay, the *Planorbis* cherts of Mount Elder and inland lake deposits—as not more than 50 feet.

2.—Description of the Rock.

A compact shelly chert. Colour, pale ochreous-grey to liver-brown on the fractured surface, relieved by occasional dark, almost black patches. The white to cream-coloured molluscan shells are conspicuous as casts and moulds, often with the shell adhering. They tend to become loose when the rock is broken, due to the partial removal of the original shell. The large shells (*P. hardmani*) range from 4 to 21 mm. in diameter, and there is also a flatter and much smaller form of the genus present (*P.* cf. *essingtonensis*). The original shelly layer of these planorbids frequently lies within the mould and can be dissolved away by a weak solution of hydrochloric acid.

On the surface of one of the chert specimens there occurs a form of *Bullinus* which does not seem referable to any known species.

3.—Its Siliceous Condition with Reference to the "Duricrusts."

The old term, "Desert Sandstone," was coined by Richard Daintree in 1872 for the horizontal beds of coarse grit and conglomerate found on the eastern branches of the Upper Flinders River and elsewhere, and which he regarded as Cainozoic in

Queensland. Since then the name has been used to include various waste deposits of sands, conglomerate, laterites and lake deposits, the results of peneplanation, ranging in age from Triassic to Pleistocene (Bryan, 1928, pp. 25, 26).

The elimination of the name "Desert Sandstone" was proposed by E. C. Saint-Smith (1914, p. 20), on the ground that it included Sandstones of the Trias-Jura, upper sandy beds of the Rolling Downs formation, lateritic cappings of Kaolin sandstones from the same, and the gravel waste from Tertiary fluviatiles. H. I. Jensen in the same year (1914, pp. 5 and 6) shows that the name "Desert Sandstone" had been misapplied to four distinct ages of rocks and in his last division he included fluviatile beds as the *Helix* sandstone of the Barkly Tableland, into which division the *Planorbis* cherts of the Mount Elder Range would fall.

With especial reference to the varied lithological aspects of the so-called Desert Sandstone, Dr. W. G. Woolnough has suggested a very apposite term for these superficial and generally hardened rocks (1927, pp. 17-53), and in his presidential address to the Royal Society of New South Wales for that year, he elaborates his term of "Duricrust." He discusses the phenomenon of an extensive peneplanation of Australia in Post-Cretaceous, possibly Miocene times. This has resulted in extensive areas of certain regions, which are alternately very dry and very wet, being covered with a mineralized deposit formed *in situ*. Lake accumulations formed long before the general peneplanation, on flat-topped hills, have also been subject to a later stage of duricrust formation. Such an instance is that of the fluviatile chert of Mount Elder.

Amongst older formations that have been "case-hardened" by a duricrust the writer has lately described (Chapman, 1933), some Cretaceous glauconitic cherts from Davis River and Spinifex Well, W.A., and containing casts of foraminifera and coccoliths; they were found closely associated with a Nullagine series in this part of Western Australia.

4.—Planorbis Hardmani and Its Affinities: the Other Mollusca Present.

Class GASTEROPODA.

Order PULMONATA.

Family LYMNAEIDAE.

Genus **Planorbis** Geoffroy, 1767.

PLANORBIS HARDMANI (McCoy, M. S.) Wade.

(Pl. VI., Figs. 1, 2.)

Planorbis hardmani McCoy M.S. in Hardman, 1885, pp. 7 and 15.

Planorbis hardmani Wade, 1924, pl. i., figs. 2-4.

Note.—Sir Frederick McCoy does not seem to have given any description of this species named in Hardman's Report; it is therefore a cheironym. Subsequently, Dr. A. Wade figured this fossil, though without description, under the above name; since a figure alone with the name attached satisfies the requirements of nomenclature, Dr. Wade becomes the author.

Description.—Shell large, for an Australian species, discoidal; body whorl evenly rounded on one face and depressed on the other. Inner whorls evolute; umbilicus deeply concave on the side with inflated whorls, and less so on the depressed side. Back rounded, sloping obliquely towards the tumid and umbilicated side. Mouth subquadrate, almost lunate, blunt at one extremity and tapering at the other. Shell thin, consisting of three layers, the inner nacreous, as seen on the fractured rock; the periostracum seems to be preserved as a dark and sometimes silicified skin.

Dimensions of Lectotype.—(Wade's figure, pl. I., top right-hand). Greatest diameter of lectotype, 21 mm. Height of shell, 8 mm. (Wade—"in private collection in London or Natural History Museum"—in litt. 15.5.37.)

Dimensions of Paralectotype, here refigured on pl. VI., fig. 1 (Wade's figure, pl. I., middle fig. of group, slightly under natural size). Height of shell, 6.25 mm. Height of aperture, 7.25 mm. Greatest diameter, 17.25 mm.

(This paralectotype is in the palaeontological collection at Canberra.)

Many smaller examples of this species, deep-whorled in its younger stages, are seen in the matrix, down to 4 mm. in diameter.

Relationships.—Most of the living Australian species of *Planorbis* are smaller, flatter, and more usually carinate. *P. hardmani* resembles the European *P. corneus* Linné, in its large size, deep rounded whorls, wide and deep umbilicus, and in its well-marked growth-lines. *P. hardmani* differs from the European species in having a roundly quadrate aperture, as against the oblique and nearly round one of *P. corneus*. *Planorbis corneus* derives its trivial name from the horny or corneous periostracum, which in that species is of considerable thickness. That the Australian species also possessed this character to a large degree is evident from portions of the shells seen in thin section of the Kimberley rock, and it even retains its characteristic horn-brown colour and conchioline structure amidst the siliceous replacement of the rest of the shell and its infilling.

Other Freshwater Mollusca in the Kimberley Silicified Limestone.

Planorbis cf. essingtonensis E. A. Smith.

Planorbis essingtonensis E. A. Smith, 1882, p. 294, pl. vi., figs. 33-35.

Several examples of a small planorbid occur on the fractured surfaces of the silicified limestone specimens, which can be

separated from the young of *P. hardmani* by certain of the following characters:—

The shell is small, flatly discoidal, and so far as visible, not distinctly umbilicated; the whorls of four turns are narrow, with indications of growth-lines, and with rounded contour, making the suturation distinct; aperture very slightly expanded; diameter 3.25 mm.

It agrees with *P. essingtonensis* in its compressed form, character of the spire, number of volutions and absence of carination except in the adult, as well as in dimensions. *P. essingtonensis* came from freshwater lagoons at Point Smith, Port Essington, about 470 miles N.E. of Mt. Elder. Another species of *Planorbis*, found living in many parts of Australia is *P. gilberti* Dunker; this species, however, is more distinctly keeled, and the last whorl suddenly increases in width.

Genus **Bullinus** Oken, 1815.

BULLINUS sp. nov.

A mould of a small, shortly turreted species of this genus occurs in this silicified limestone. A wax squeeze indicates a small, roundly ovate shell of four whorls, slight angulation at the shoulder, and deeply impressed sutures; the body whorl shows faint spiral lirae. In some respects it resembles *B. aliciae* (Reeve), but the short spire and more ovate shell proves it to be distinct.

In the study of these mollusca the writer has had the advantage of the experienced assistance of Mr. C. J. Gabriel.

5.—Description of Other Associated Organisms, in Thin Section.

The matrix of this rock, originally a travertine or calcareous lacustrine mud, is still partly calcareous. This mud surrounds the shells of *Planorbis*, filling their outer whorls; in places it is seen to show a laminate, spherical habit, as in the blue-green algae (*Cyanophyceae*). A quantity of fine, granular material is present, probably representing the undigested food of the snails.

The silicification of this rock is extremely interesting; interstices between the calcareous granules and pellets are filled in with chalcedonic or cryptocrystalline silica. The remaining part of the cavity of the *Planorbis* shell is filled with a mosaic of polysynthetic quartz, which presents a striking appearance under crossed nicols. The shells themselves are partly silicified, the inner and outer layers, originally fibrous and conchiolitic, retaining their characteristic horn-brown tint.

Occurrence of Plant Remains.

In a thin slice prepared from the darker and denser part of this chert, I have been able to recognize minute tubular calcareous plants, that are most likely referable to a filamentous alga such as *Cladophora*. Similar plant remains have been described by the writer from opal nodules of Pleistocene age from the Richmond River, New South Wales (Chapman, 1922, p. 169), under the name of *Cladophora richmondiensis*.

There are also traces of charophytes (fragments of stems and nucules (pl. VI., fig. 5)).

Occurrence of Foraminifera.

At the present time the Elder Range lies 160 miles in a direct line from the coast at Cambridge Gulf. The discovery of the existence of minute tests of foraminifera in the fine granular matrix of the freshwater silicified limestone on the plateau of the Ord River Basin points to their possible aeolian origin from a shore-line in early Pleistocene times when the present coast in the vicinity of the Ord River Basin extended farther inland. With regard to the carrying of foraminifera and other minute organisms inland from the marine shore-line, another instance may be cited of foraminifera-bearing dune-sands in the Girnar Hills of India, 30 miles away from the sea (Chapman, 1900, p. 586). The following forms have been identified in the matrix:—

Globigerina sp. near *bulloids* d'Orb. (pl. VI., fig. 3, 4); cf. *Discorbis*; *Trochammina* sp.; and *Spiroplectammina* sp.

Occurrence of Sponges.

In thin section, particularly of the denser part of the chert, there is evidence of acerate spicules with numerous cross sections of cf. *Spongilla*, a freshwater sponge (pl. VI., fig. 6).

Occurrence of Ostracoda.

In the thin section of this freshwater limestone there occur numerous fragments of ostracods, only one of which, however, can here be identified. This is the freshwater form, *Newnhamia* cf. *fenestrata* King (Henry, 1923, p. 270, pl. XXIV., figs. 1-10). The species at present has a wide distribution, having been recorded from New South Wales, New Zealand, and the Bismarck Archipelago.

Occurrence of Insect Fragments.

In the denser part of the chert, numerous fragments of probable insect remains of an umber brown colour are seen in thin sections (pl. VI., fig. 6).

6.—Evidence of Age.

Ideas as to the probable age of the *Planorbis*-bearing limestones or cherts of the Mt. Elder Range of North-western Australia are somewhat conflicting, but they mostly range about late Tertiary or Pleistocene. L. Glauert expressed the opinion (Glauert, 1926, p. 52) that "The cherty beds of Mt. Elder, East Kimberley containing the gasteropod *Planorbis hardmani* may probably be found to be of Cretaceous age when a more detailed examination of the fossil contents is undertaken". He does not, however, advance any direct evidence which would support this suggestion.

Dr. Wade's own observations (*loc. supra cit.*) led him to believe that the *Planorbis* cherts were laid down in Tertiary times.

From a general survey of comparative evidence in other parts of the continental peneplain, the most tenable view, coinciding with that expressed in my former, preliminary, report on this collection (Chapman, 1924, p. 3) is that their age is most probably Post-Tertiary (Early or Middle Pleistocene). They are thus practically synchronous with the *Helix* Sandstone of the Bass Strait Islands, in regard to which Sir Edgeworth David came to a similar conclusion in the British Association Handbook, "The Geology of the Commonwealth" (David, 1914, p. 255), where he also linked up the *Helix* limestone of the Cloncurry district in Queensland.

Finally, some good evidence of a Pleistocene duricrust has been discovered in the Eastern Macdonnell Ranges by Dr. C. T. Madigan (1932, p. 98), who, referring to the flat tops that slope gently down the south side of Paddy's Hole Plain, states that limestone rises to 50 feet, covered with spinifex. Dr. Madigan states that "The limestone was found to be formed almost entirely of *Planorbis* shells, and is a freshwater limestone, indicative of lacustrine conditions on the plain in former times. . . . Mr. F. Chapman . . . wrote that the *Planorbis*, while unlike the usual numerous keeled species living in Australian freshwater streams, and lakes, resembled *P. hardmani*, the supposed Pleistocene species of the north-west, though of much smaller dimensions".

Such fluviatile deposits, always in the vicinity of the present river systems, are apparently synchronous with the bone beds of the King's Creek, Maryvale Creek, the Condamine River, and other localities in Queensland and elsewhere. These have yielded in abundance fossil remains of the large extinct marsupials, sometimes associated with such freshwater molluscs as *Corbicula nepeanensis* (Lesson), *Bullinus truncatus* (Adams), *and Lymnaea vinosa* (Adams and Angas).

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Explanation of Plate. VI.

Fig. 1.—*Planorbis hardmani* Wade. Paralectotype. Lacustrine cherty limestone. Hill J40. Mt. Elder Range, Kimberley District, W. Australia. Nat. size.

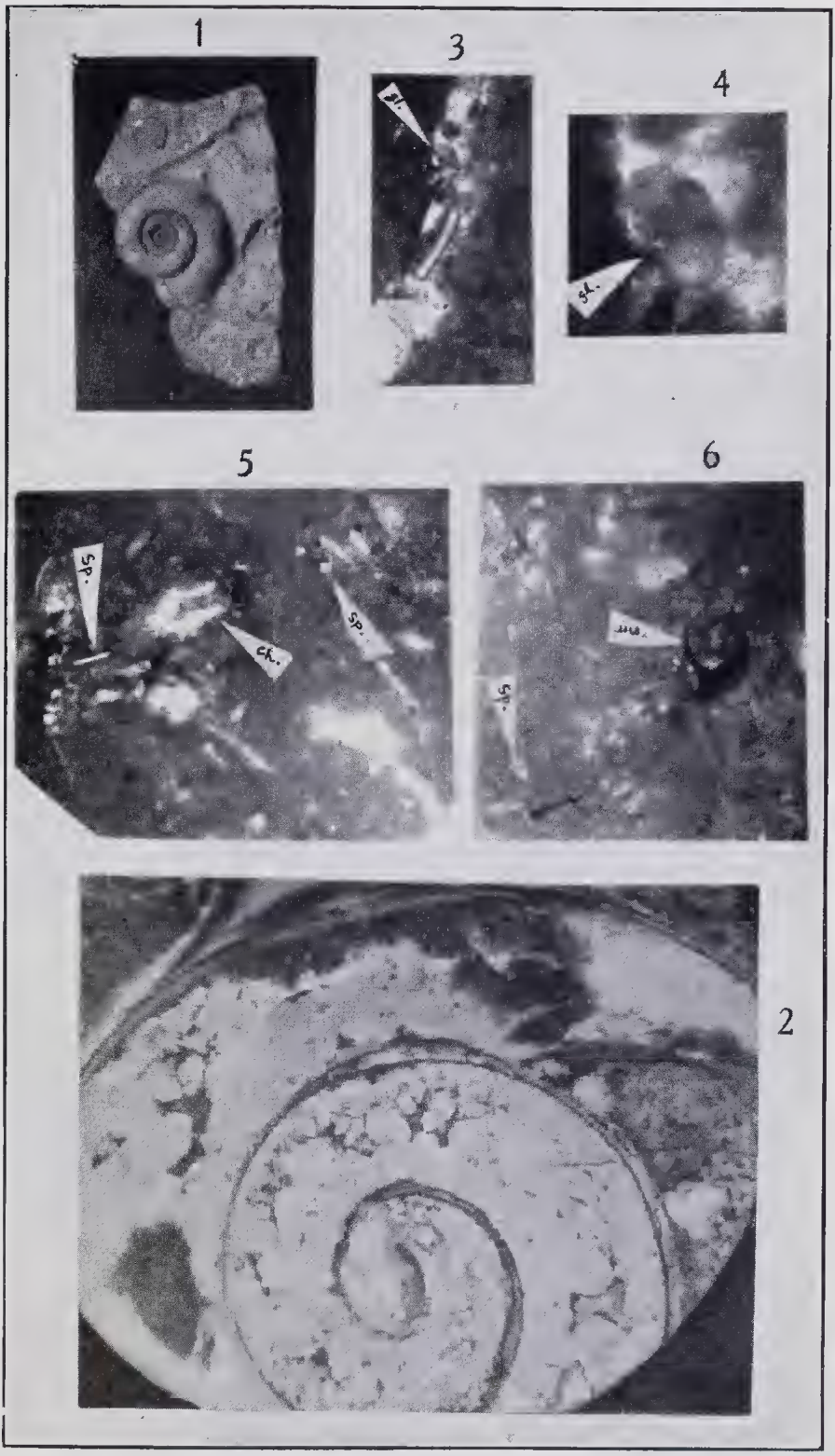
Fig. 2.—*P. hardmani* Wade. Horizontal section of shell in matrix. Shows infilling of calcareous mud and invading polysynthetic quartz. Also shell with three-fold layers. × 18.

Fig. 3.—Section of *Planorbis* limestone, with a test of *Globigerina* aff. *bulloides* (gl.), measuring 0.114 mm. in diameter. × 44.

Fig. 4.—The above *Globigerina* test (gl.), more highly magnified. × 166.

Fig. 5.—Section of *Planorbis* limestone, showing stems of charophytes (ch.) and freshwater sponge spicules (sp.). × 18.

Fig. 6.—Section of *Planorbis* limestone, with an insect fragment (ins.) and numerous freshwater sponge spicules (sp.). × 28.



F. C. photo.]

Planorbis Limestone.—Mt. Elder, Kimberley, W. A.

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